Space Weather Technical Forecast

Issued on Thursday 19 December 2024 at 01:21 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: Chance of M-class flares (R1-R2; Minor-Moderate Radio Blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with a peak C8.2 flare at 18/0734 UTC, most likely from a region emerging around the east limb. There are nine sunspot regions on the Earth-facing disc. AR3924 (Eko/Beta-Gamma) remains the most complex sunspot group on the disc, but the region has shown stability. AR3922 (Dai/Beta) after showing the most growth in the last 48 hours has begun to slow in any developments and has remained stable. All other spots remain magnetically simple. No Earth-directed CMEs were observed.

Solar Wind / Geomagnetic Activity: Solar winds, at L1 were observed just above 500km/s by DSCOVR but also measure closer to 600km/s by ACE (currently some uncertainly between the two spacecraft) with a slight trend downwards towards the end of the period. Density remains below average following from the impact of the CME on 17 Dec. The Interplanetary Magnetic Field (IMF), Bt, remained weak, around 5-7nT throughout. The north-south component, Bz, fluctuated between -5nt and +7nT. The phi angle was predominantly negative (towards the Sun). Geomagnetic activity was largely Quiet to Unsettled (kp1-3) with Active intervals (Kp4).

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was background, with a diurnal peak at Moderate levels. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold. The 19/0000 UTC observation was 5.45e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate Solar activity is forecast with a chance of M-class flares, increasing gradually through the forecast period.

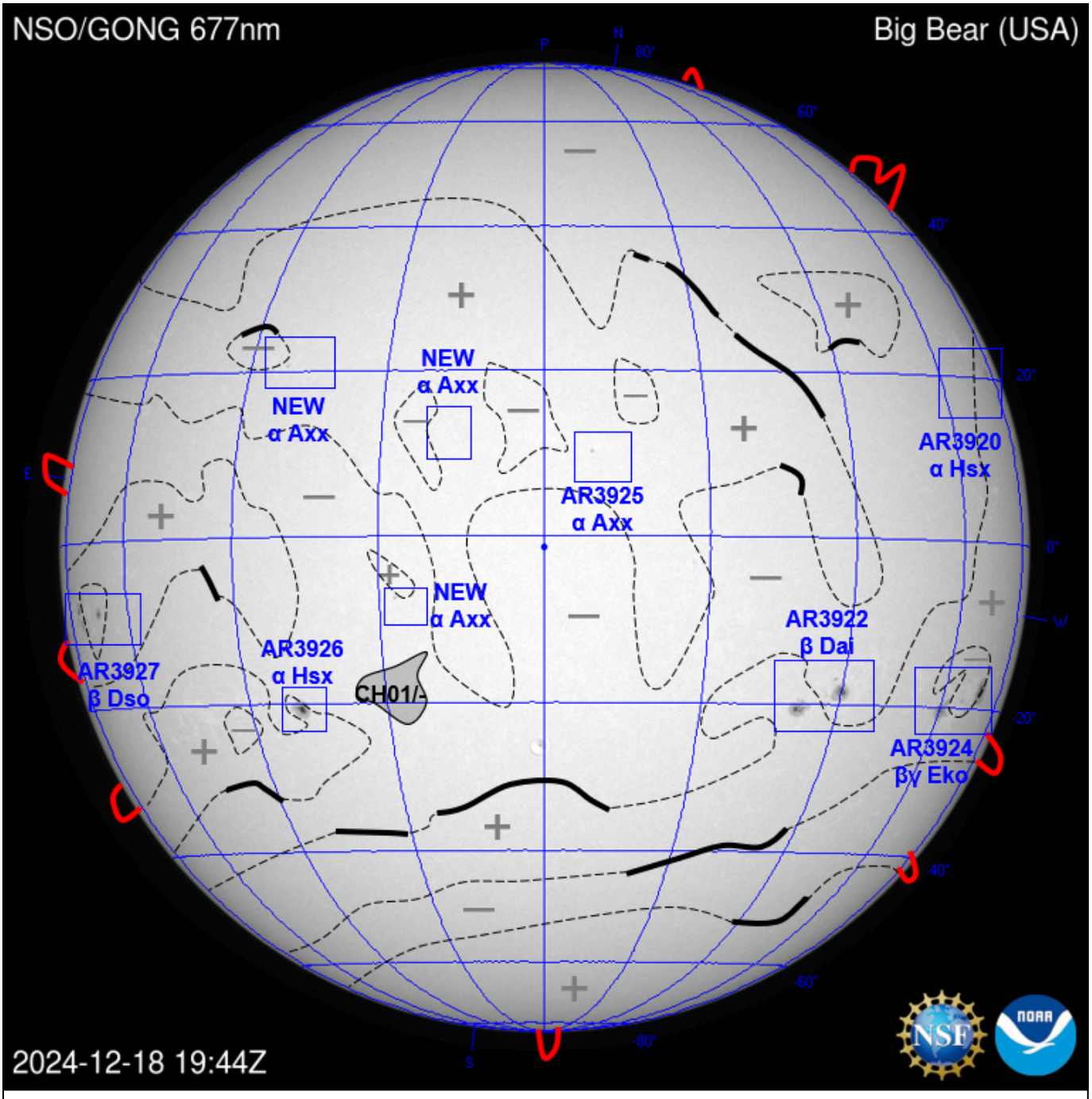
Solar Wind / Geomagnetic Activity: The CME experienced at Earth during the morning of 17 Dec has largely passed, with Quiet to Unsettled (Kp1-3) activity expected. Although, solar wind speeds remain elevated with Active (Kp4) intervals likely during Day 1 (19 Dec) and a slight chance of G1/Minor Storm (Kp5). Several other CMEs that left the Sun in the past few days are forecast as near misses, but cannot be completely ruled out as flanking arrivals at Earth, so there is some uncertainty in the forecast currently.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background, but carries a slight chance of reaching S1/Minor Storm levels, in response to any notable solar flares. High energy electron flux may increase to moderate with diurnal peaks of high. However, the 24-hour fluence is expected to remain below the Active threshold throughout.

Figure 1: Solar Synoptic Map valid 18/1944 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Geomagnetic Storms

The unexpected CME which arrived at Earth early on the 17 Dec is thought to be associated with a large and complex filament eruption that occurred early on the 15 Dec. Most of the ejecta from the filament appeared to go south and west out of the solar system and away from Earth, but there was evidence of a very faint and fast shock front emanating from the Sun shortly afterwards, as seen only on STEREO A coronagraph. While the main geomagnetic impacts have passed, solar winds remain Elevated with further Active intervals likely. A gradual decline is anticipated to Slightly Elevated levels and by Day 2 (20 Dec) will probably be at Slow-Ambient levels. Geomagnetic activity is now at Quiet to Unsettled (Kp1-3) levels. Any previous estimations of CME arrivals are likely to have been swept up and are no longer forecast to have any impact on Earth, although this is perhaps the main source of uncertainty in the forecast.

A very fast halo CME was evident in LASCO imagery around 17/1600 UTC, however this appears with good confidence to be far-sided with minimal impact to Earth. There have been no further significant CMEs observed in the Earth-Sun line. A small coronal hole, CH01-, has developed in the eastern hemisphere, this doesn't appear to be a persistent feature and any connection to the HSS from it, is likely to be after the current forecast period and most likely rather weak given the proximity to the winter solstice.

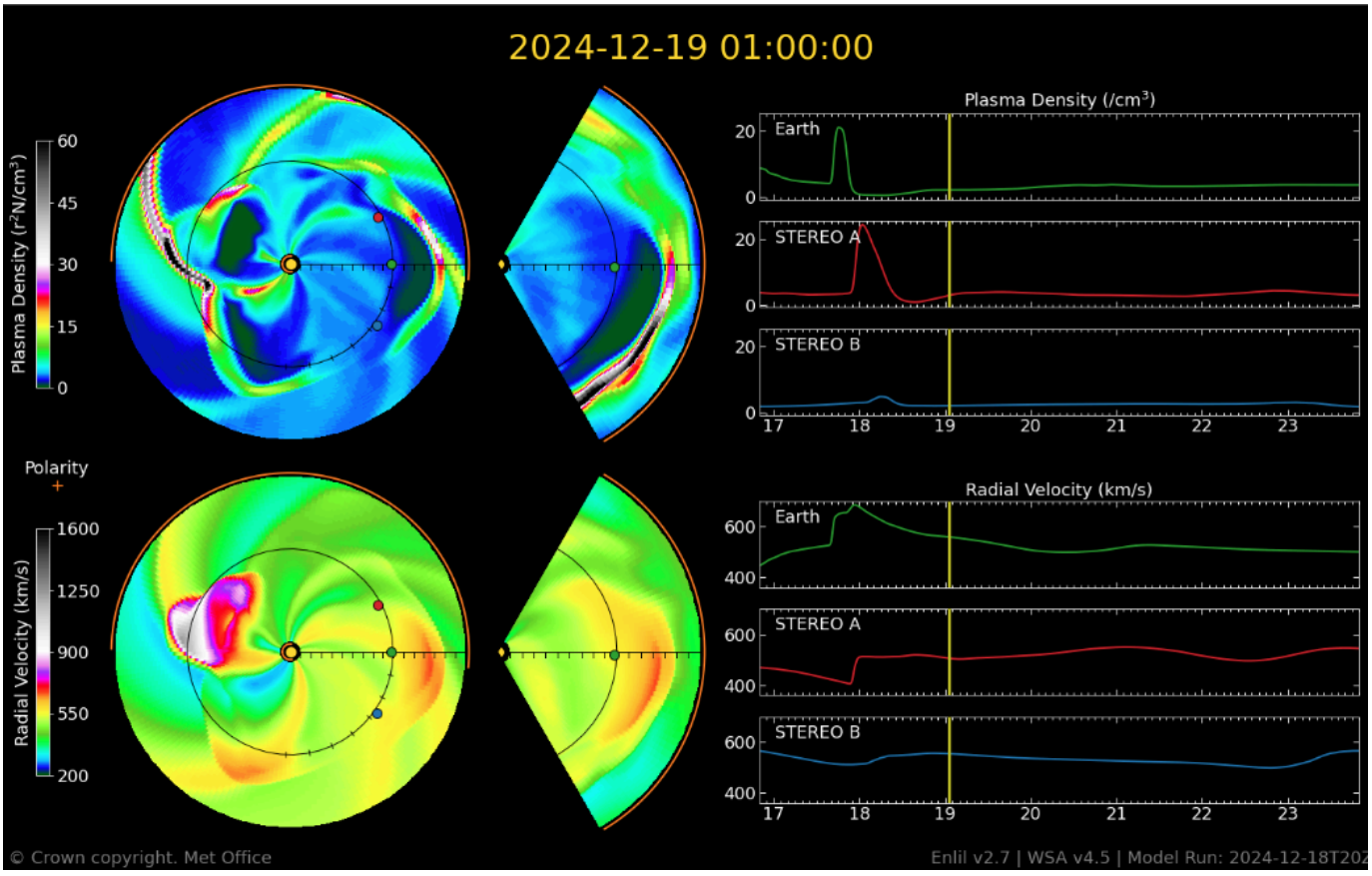
Geomagnetic activity is expected to be largely Quiet to Unsettled (Kp1-3) throughout, with Active (Kp4) intervals likely and a slight chance of G1/Minor Storm during Day 1 (19 Dec).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	20	10	5	5
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Figure 2: MOSWOC Enlil



© Crown Copyright 2024. All Rights Reserved.

Radio Blackouts - X-Ray Flares

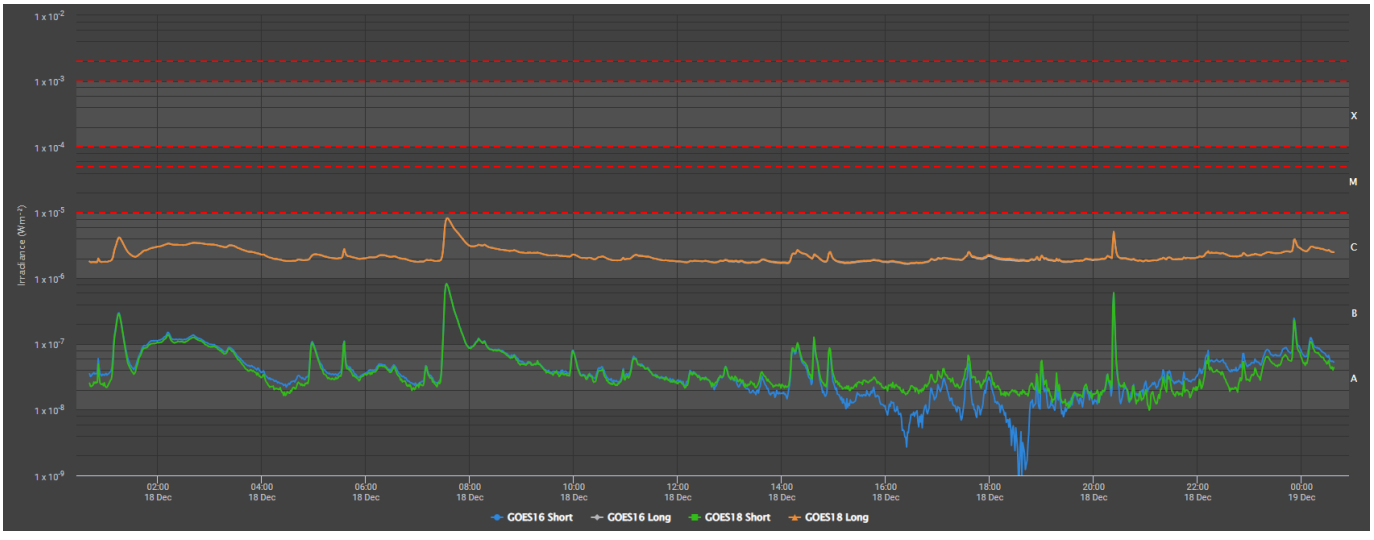
There are nine sunspot regions on the Earth-facing disc. AR3924 in the southwest, remains the largest and most complex region, consisting of a large, symmetric leading spot and a similarly sized and more irregularly shaped trailing spot although has shown little development in the last 24 hours. AR3922 is the second largest with a hint of intermediate spots, but has remained similar in size and magnetic complexity in the last 24 hours. The newly numbered AR3927 has made its way further on to the disc and is one to watch, showing signs of magnetic complexity with notable looping in imagery. The remaining regions on the disc are smaller and magnetically simple.

Solar activity is currently Low, although with the emergence of further sunspot regions expected to rotate onto the disc from over the east limb between Days 1 and 2 (19-20 Dec) the chances of M-flares increases with time as shown in the table below. These regions perhaps corresponding to Ex-AR3905 and Ex-AR3906. With the largest C-class flare most likely from around the eastern limb. Both these regions produced M-class flares when they were last on the Earth-facing disc and recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

Low to Moderate solar activity with a chance of isolated M-class flares on Day 1 (19 Dec), M-class flares then becoming likely by Day 2 (20 Dec). Slight chance of isolated X-class flares throughout.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	No	40	60	60	60
Very Active	R3-R5 (X Class)	No	2	5	5	5

Figure 3: GOES16 & 18 X-ray trace.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

Solar Radiation Storms (High Energy Protons)

GOES18 proton flux is at background levels. There is a continuing slight chance of reaching S1/Minor Storm levels, in response to any notable solar flares, currently most likely from AR3924 and AR3922. AR3924 will likely rotate over the western horizon on Day 2 (20 Dec), shortly followed by AR3922, but proton storm probabilities are maintained for at least 24-hours after it leaves the visible disc. In the meantime, other regions look magnetically simple and any other complex groups that may rotate on to the disc will remain the in the eastern hemisphere for the forecast period.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 370 900 0100 Email: enquiries@metoffice.gov.uk

© Crown Copyright 2024. All Rights Reserved.

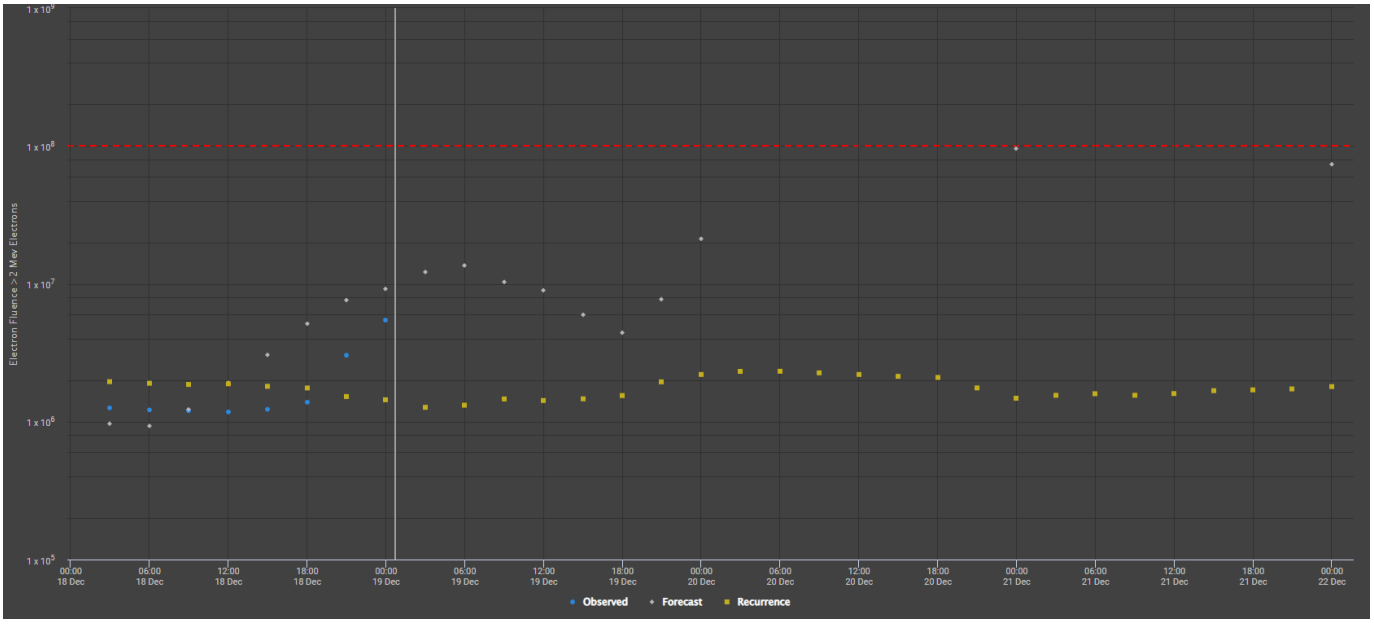
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been at largely background levels, diurnally rising to Moderate following the influence of the recent CME arrival on 17 Dec. The CME likely caused the electron belts to become compressed away from GEO. However, as the CME influence wanes the Van Allen belt will continue to relax and expand back towards GEO in the coming days. As a result, the electron flux at GEO may rise to moderate, perhaps peaking a high levels within the diurnal cycle.

The associated 24-hour fluence may rise a touch, but is expected to remain below the Active (1e8 integrated flux) threshold throughout the forecast period. MOSWOC REFM output is considered to be providing good guidance.

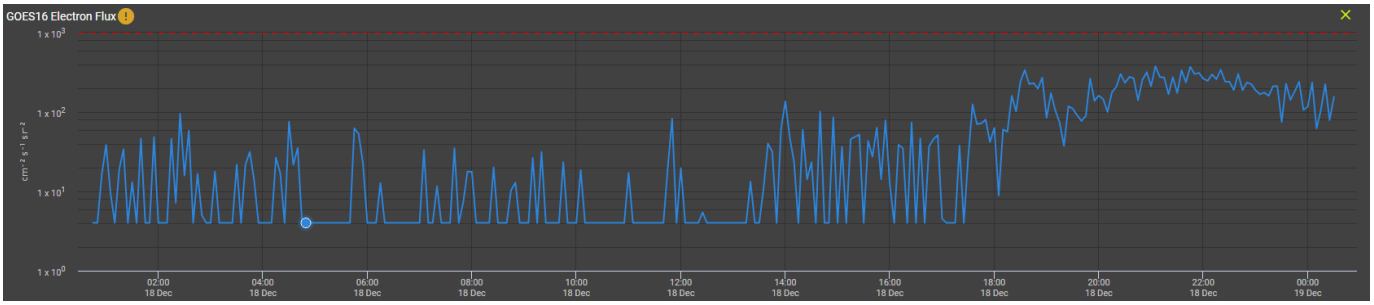
GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	10	10	5
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 4: MOSWOC REFM output



© Crown Copyright 2024. All Rights Reserved.

Figure 5: GOES 16 Electron Flux



© Crown Copyright 2024. All Rights Reserved.